Journal of Forensic and Legal Medicine 18 (2011) 79–81

Contents lists available at ScienceDirect

Journal of Forensic and Legal Medicine

journal homepage: www.elsevier.com/locate/jflm

Original Communication

Gender differentiation by finger ridge count among South Indian population

M.D. Nithin MD Assistant Professor *, B. Manjunatha MD Professor, D.S. Preethi MBBS Medical Student, B.M. Balaraj MD, D.FM Professor & H.O.D

Department of Forensic Medicine and Toxicology, J.S.S University, J.S.S. Medical College, Sri Shivarathreeshwara Nagar, Bannimantap, Mysore 570015, Karnataka, India

ARTICLE INFO

Article history:
Received 25 June 2009
Received in revised form
25 October 2010
Accepted 6 January 2011
Available online 23 January 2011

Keywords:
Fingerprint
Ridge density
Baye's theorem
Personal identification
Gender
South Indian population

ABSTRACT

The goal of this study is to determine the gender based on finger ridge count within a well-defined area. Rolled fingerprints were taken from 550 subjects (275 men and 275 women) belonging to South Indian population all within the age range of 18–65 years. Results show that women have a significantly higher ridge count than men. Application of Baye's theorem suggests that a fingerprint possessing ridge density $<$13 ridges/25 mm^2 is most likely to be of male origin. Likewise, a fingerprint having ridge count $>$14 ridges/25 mm^2 are most likely to be of female origin. These results are helpful as a tool for fingerprint experts as they can be used as a presumptive indicator of gender based on the degree of ridge density.

1. Introduction

Dactylography is the process of taking impressions of the pulp of the fingers and thumbs on an unglazed white paper and examining them with a magnifying lens.[1] Although fingerprints have been noted and used since antiquity, a 25-year burst of activity that secured adoption of their use for identification began about 1880s. New modifications and applications have continued to the present.[2] No two fingers are found to have identical prints, and it is an overwhelming mathematical probability that no two ever will be found to match.[3] It has long been recognized that the fingers, palms of the hands and soles of the feet of human bear friction ridge skin. These areas are characterized by a complicated pattern of "hills and valleys". The hills are called ridges and the valleys furrows.[4]

Many studies have been carried out on the method of storing fingerprints, for rapid search and matching of fingerprints in computers around the world, but very few studies[5–7] are available on determining the gender of an individual from friction ridge count of a fingerprint. Hence this study was taken up to determine the gender of an individual from finger ridge count among South Indian population.

2. Materials and methods

The study was conducted in the department of Forensic Medicine and Toxicology, J.S.S. Medical College, Mysore, India. In this study 550 subjects (275 men and 275 women) were randomly picked from South Indian population, all within the age group of 18–65 years. Non Resident Indians and subjects from Central, Western and Eastern India were excluded from the study. Subjects with any evidence of disease and injury of the fingertips that was likely to alter the fingerprint pattern (leprosy, scars of the fingertips, lacerations, etc.) were excluded. Informed written consent was obtained prior to taking the prints. The materials used for this study were pre-inked strips measuring 250 × 75 mm, a foldable magnifying lens of 8× magnification, transparent film strip, pencil, measuring scale and proforma.

The subjects were asked to wash and dry their hands to remove dirt and grease. They were asked to keep their hand relaxed and not to try to help in rolling the fingers as this may cause smudging. The level of the printake strip was placed in such a way that there was no strain or pressure on the fingers.[8] It was placed at the edge of the table, so that the subject's fingers which are not being printed will not interfere with the manipulation of other fingers in printing process.[8] It was placed at a sufficient height to allow the subject's forearm to assume a horizontal position when fingers are inked.[9] Excessive pressure on the fingers while inking and recording was avoided. Then the fingers were rolled from nail to nail over the printake strip, taking

* Corresponding author. Tel.: +91 8232 221678, +91 98453 78227(M); fax: +91 821 2493819.
E-mail address: nithin7755@rediffmail.com (M.D. Nithin).

1752-928X/$ – see front matter © 2011 Elsevier Ltd and Faculty of Forensic and Legal Medicine. All rights reserved.
doi:10.1016/j.jflm.2011.01.006

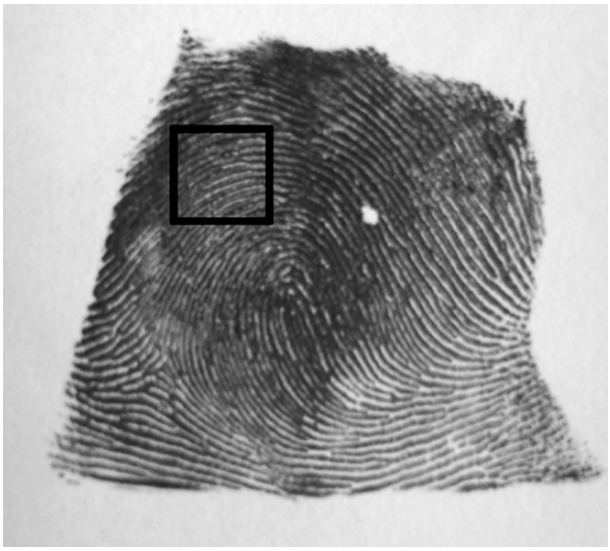

Fig. 1. Technique used to count dermal ridges in this study. All the ridges within the depicted 5 mm × 5 mm were calculated.[7]

care to ink the complete ridge pattern of distal phalanx and upper portion of the middle phalanx. After the right hand fingers were inked, the fingers were rolled in an appropriate position on the proforma. The fingers were rolled away from the body of the person.[8]

$$\text{LR} = \frac{\text{Probability of a given fingerprint originating from male contributor (C)}}{\text{Probability of a given fingerprint originating from female contributor } \left(C^1\right)}$$

The same was repeated for the left hand. In this way, for each and every individual rolled fingerprints of all ten fingers were obtained. Rolled fingerprints were taken because they show the full pattern area including deltas and all ridge characteristics.

After taking the fingerprints, the upper portion of the radial border of each print was chosen as an area for the data collection, because all fingerprint pattern types showed a similar ridge flow in this region.[10,11] In this selected area, epidermal ridges of both men and women were counted carefully within a square of 5 mm × 5 mm drawn on a transparent film fixed to a lens.[10–12] Counting started from one corner of the square to the diagonally opposite corner in a zigzag manner.[12] Fig. 1 depicts the technique used to count the ridges in this study.

The traditional ridge counting methods were not used in this study because of the fact that arches lack ridges according to traditional ridge count method, yet do not lack epidermal ridges in the biological sense.[12] Ridge thickness and furrows are two important factors which determine density of ridges.[10–12] Since ridge counting was done within a well-defined area, both these parameters have been considered in this study. Error rates were considerably reduced as ridge counting was done by two researchers.

After the ridge counts were done individually for all the ten fingers, the mean value was calculated. Data was analysed statistically using SPSS (Statistical Programme for Social Sciences) version 14.0. The alpha level of significance was set at 0.05 for all statistical calculations. The likelihood ratio (LR) was calculated to obtain the probability inferences of gender, based on ridge density values. This likelihood ratio was based on Baye's theorem.[13]

Table 1
Descriptive statistics of ridge density in both males and females.

Descriptives		Males	Females
Mean		12.5716	14.1455
Median		12.7000	14.1000
Mode		12.00	14.00
Standard deviation		1.49361	1.68411
Variance		2.231	2.836
Range		6.90	7.90
Minimum		9.50	9.50
Maximum		16.40	17.40
Percentiles	25	11.5000	13.3000
	75	13.5000	15.3000

Table 2
Probability densities & likelihood ratios derived from observed ridge count.

Ridge count	Probability density		Likelihood ratio		Favored odds	
	Male (C)	Female (C^1)	LR (C/C^1)	LR (C^1/C)	Male	Female
10	0.09	0.02	4.50	0.22	0.2692	0.7308
11	0.14	0.05	2.80	0.35	0.3131	0.6869
12	0.22	0.08	2.75	0.36	0.3296	0.6704
13	0.28	0.13	2.15	0.46	0.3023	0.6977
14	0.16	0.26	0.61	1.625	0.1041	0.8959
15	0.06	0.22	0.27	3.66	0.0161	0.0839
16	0.02	0.13	0.15	6.5	0.0297	0.9703
17	0.001	0.08	0.01	80	0. 0	1.0000

3. Results

Descriptive statistics of ridge density in both males and female subjects are shown in Table 1.

The mean value of ridge density for male was 12.57 and that of female was 14.14.

Table 2 shows the probability density for men (c) and women (c^1) and using these values, the likelihood ratios (c/c^1) and (c^1/c) were calculated.

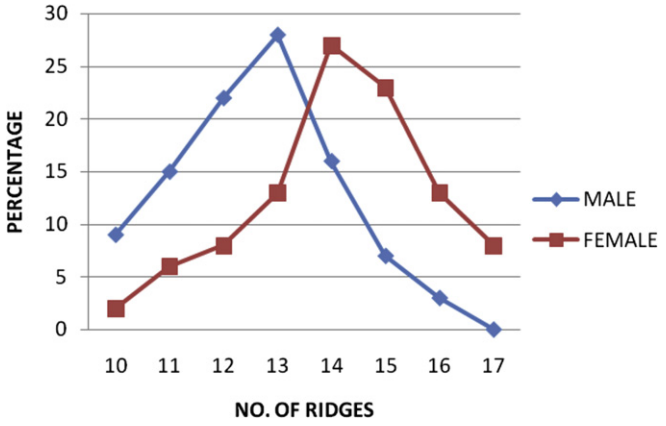

Fig. 2. Frequency distribution of dermal ridge density observed from males and females of South Indian population.

Table 3
Gender differentiation by finger ridge count among various studies.

Author	Race	Mean ridge count	
		Male	Female
Reddy CC[14]	Bagatha's of Araku Valley India	13.41	12.04
Acree	African American	10.90	
Cummins and Midlo[15]	American	20.7	23.4
Sudesh Gungadin	Karnataka, India	12.8	14.6
Vinod C. Nayak et al.	Karnataka, India	11.05	14.2

The statistical analysis of likelihood ratio and odds ratio shows that ridge count $\leq$13 ridges/25 mm^2 is more likely to be of male origin ($p = 0.30$), whereas ridge count $\geq$14 ridges/25 mm^2 is more likely to be of female origin ($p = 0.89$).

Posterior probability using Baye's theorem[13] shows that a fingerprint with ridge count of $\leq$10 ridges/25 mm^2 will have a higher probability to be male ($p = 0.26$). Similarly, a ridge count of $\geq$17 ridges/25 mm^2 will be more indicative of females ($p = 1.0$), while there was no male found in this category (Fig. 2).

4. Discussion

Various studies[5–7] have been conducted on ridge count, mainly for race determination and genetic inheritance, but not many studies[10–12] have been conducted for gender determination by fingerprint ridge count. This study shows that women of South Indian origin have significantly higher ridge count (mean = 14.14) when compared to men (mean = 12.57).

The results obtained in this study are similar to those obtained by Sudesh[10] and higher values obtained by Acree.[12] The results of this study are quite encouraging and would be helpful as a tool for forensic experts and law enforcement.[10] As it demonstrates that females tend to have a finer ridge density than men, the degree of ridge density can be used as a presumptive indicator of gender of an unknown print left at a crime scene.[12] This can be achieved simply by qualitatively examining if prints appear coarse or fine and then rapidly quantifying ridge density in a manner analogous to methods described in this study (Table 3).

5. Limitations

In this study 550 subjects of South Indian population were considered. Similar studies must be carried out on a larger population and focus on people from various racial origins. Additionally, further replicate studies should be conducted on South Indian population. If these limitations are overcome, then gender differentiation by finger ridge density would be much more valuable and accurate.

6. Conclusion

The results of this study support the hypothesis that women commonly have greater ridge density than males. The differences between male and female ridge density are statistically significant, with the ridge count of $\leq$13 ridges/25 mm^2. The results show that women have more ridge density than men.

Conflict of Interest
None declared.

Funding
None.

Ethical approval
None.

References

1. Vij K. *Textbook of Forensic Medicine. Principles & Practice*. 1st ed. New Delhi: Churchill Livingstone Pvt.; 2001. p. 89.
2. Caplan RM. How fingerprint came into use for personal identification. *J Am Acad Dermatol* 1990 Jul;**23**(1):109–14.
3. Cunliffe F, Piazza PB. *Criminalistics and scientific investigations*. New Jersey: Prentice Hall Inc.; 1980. p. 266.
4. Robert EG, Kimberly RY. *Fingerprints as evidenceForensic Science: an introduction to scientific and investigative techniques*. 2nd ed. Boca Raton, Florida: Taylor & Francis, CRC Press; 2005. p. 342.
5. Jantz RL. Sex and race differences in finger ridge – Count correlations. *Am J Phys Anthropol* 1977;**46**:171–6.
6. Okajima M. Frequency of fork in epidermal ridge minutiae in fingerprint. *Am J Phys Anthropol* Jan–May 1970;**32**:41–8.
7. Moore RT. Automatic fingerprint identification systems. In: Lee HC, Gaensslen RE, editors. *Advances in fingerprint technology*. Boca Raton, Florida: CRC Press; 1994. p. 169.
8. Nithin MD, Balaraj BM, Manjunatha B, Shashidhar C Mestri. Study of fingerprint classification and their gender distribution among South Indian population. *J Forensic Leg Med* 2009;**16**:460–3.
9. Nadar DS. *Forensic Science in crime investigation*. 3rd ed. Hyderabad: Asia Law House; 2002. p. 69.
10. Sudesh G. Sex determination from finger ridge density. *Internet J Med Update* 2007 Jul–Dec;**2**(2).
11. Vinod CN, Rastogi P, Kanchan T, Lobo SW, Yoganarasimha K, Nayak S, et al. Sex differences from fingerprint ridge density in the Indian population. *J Forensic Leg Med* 2010;**17**:84–6.
12. Acree MA. Is there a gender difference in fingerprint ridge density? *Forensic Sci Int* 1999;**102**:35–44.
13. Grieve MC, Dunlop JA. Practical aspects of the Bayesian interpretation of fibre evidence. *J Forensic Sci Soc* 1992;**32**:169–75.
14. Reddy CC. Finger dermatoglyphics of the Bagathas of Araku Valley, India. *Am J Phys Anthropol* 1975;**42**:225–8.
15. Cummins H, Midlo C. *Fingerprints, Palms & Soles: an introduction to dermatoglyphics*. New York: Dover Publications; 1961. p. 272.